

## CLAIMS

What is claimed is:

1. A cryogenic fluid delivery system comprising:
  - a. a storage tank containing a supply of cryogenic liquid;
  - b. a pump including:
    - i) a pumping cylinder having an inlet in communication with said storage tank, an outlet and a pumping piston slidably positioned therein so that cryogenic liquid from the storage tank is pumped through the pumping cylinder outlet by motion of the pumping piston;
    - ii) an actuating cylinder having an inlet, an outlet and an actuating piston slidably positioned therein;
    - iii) a supplemental linear actuator;
    - iv) said supplemental linear actuator, actuating piston and pumping piston joined by at least one connecting rod so that the pumping piston is driven by the actuating piston and the supplemental linear actuator;
  - c. a heat exchanger in circuit between the pumping cylinder outlet and the actuating cylinder inlet, said heat exchanger vaporizing a portion of the pumped cryogenic liquid so that said actuating piston is propelled by the resulting cryogenic vapor; and
  - d. a liquid delivery line also in communication with the pumping cylinder outlet so that a portion of the pumped cryogenic liquid may be delivered therethrough.
2. The system of claim 1 wherein the supplemental linear actuator is a hydraulic cylinder.

3. The system of claim 1 further comprising a pressure control circuit positioned within said liquid delivery line, said pressure control circuit selectively increasing the pressure within said liquid delivery line so that a greater portion of pumped cryogenic liquid may be directed to said heat exchanger.

4. The system of claim 1 further comprising:

e. a gas and liquid mixer in communication with the actuating cylinder outlet and the liquid delivery line so that said gas and liquid mixer receives cryogenic liquid from the liquid delivery line and cryogenic vapor from the actuating cylinder outlet so that the cryogenic liquid is warmed by the cryogenic vapor to a desired temperature; and

f. a conditioned liquid dispensing line also in communication with the gas and liquid mixer so that the warmed cryogenic liquid may be dispensed therefrom.

5. The system of claim 4 further comprising a pressure control circuit positioned in said liquid delivery line, said pressure control circuit selectively increasing the pressure within said liquid delivery line so that a greater portion of the pumped cryogenic liquid may be vaporized and ultimately directed to said gas and liquid mixer so that greater heating of the cryogenic liquid occurs therein.

6. The system of claim 1:

wherein said actuating cylinder is divided by said actuating piston into a first chamber and a second chamber, each of which includes an inlet; and

further comprising a first automated control valve in circuit between the heat exchanger and the actuating cylinder inlets, said first automated control valve introducing cryogenic vapor into said first and second actuating cylinder chambers in an alternating fashion thereby propelling the actuating piston in the first and second directions in a reciprocating fashion.

7. The system of claim 6:

wherein said supplemental linear actuator is a hydraulic cylinder including a hydraulic piston attached to the connecting rod with first and second chambers on opposing sides of the hydraulic piston, each of which includes an inlet; and

further comprising a second automated control valve adapted to communicate with a pressurized source of hydraulic fluid and the hydraulic cylinder first and second chamber inlets, said second automated control valve introducing hydraulic fluid into said hydraulic cylinder first and second chambers in an alternating fashion thereby propelling the hydraulic piston in the first and second directions in a reciprocating fashion.

8. The system of claim 7 further comprising first and second limit switches, a stroke change cam attached to said connecting rod and a controller, said controller in communication with the first and second automated control valves and the first and second limit switches, said stroke change cam tripping said first limit switch when said actuating, hydraulic and pumping pistons have traveled to a first position and said stroke change cam tripping the second limit switch when said actuating, hydraulic and pumping pistons have traveled to a second position, said controller reconfiguring said first and second automated control valves whenever said first

and second limit switches are tripped so that cryogenic vapor is redirected to a different chamber of the actuating cylinder and hydraulic fluid is redirected to a different chamber of the hydraulic cylinder.

9. The system of claim 1:

wherein said supplemental linear actuator is a hydraulic cylinder including a hydraulic piston attached to the connecting rod with first and second chambers on opposing sides of the hydraulic piston, each of which includes an inlet; and

further comprising an automated control valve adapted to communicate with a pressurized source of hydraulic fluid and the hydraulic cylinder first and second chamber inlets, said automated control valve introducing hydraulic fluid into said hydraulic cylinder first and second chambers in an alternating fashion thereby propelling the hydraulic piston in the first and second directions in a reciprocating fashion.

10. The system of claim 10 further comprising first and second limit switches, a stroke change cam attached to said connecting rod and a controller, said controller in communication with the automated control valve and the first and second limit switches, said stroke change cam tripping said first limit switch when said actuating, hydraulic and pumping pistons have traveled to a first position and said stroke change cam tripping the second limit switch when said actuating, hydraulic and pumping pistons have traveled to a second position, said controller reconfiguring said automated control valve whenever said first and second limit switches are tripped so that hydraulic fluid is redirected to a different chamber of the hydraulic cylinder.

11. A pump for transferring cryogenic fluid from a storage tank comprising:
  - a. a pumping cylinder housing defining a pumping cylinder, said pumping cylinder having an inlet adapted to communicate with said storage tank, an outlet and a pumping piston slidably positioned therein so that cryogenic liquid from the storage tank is pumped through the pumping cylinder outlet by motion of the pumping piston;
  - b. an actuating cylinder housing defining an actuating cylinder, said actuating cylinder having an inlet, an outlet and an actuating piston slidably positioned therein;
  - c. a heat exchanger in circuit between the pumping cylinder outlet and the actuating cylinder inlet, said heat exchanger vaporizing a portion of the pumped cryogenic liquid so that said actuating piston is propelled by the resulting cryogenic vapor;
  - d. a supplemental linear actuator; and
  - e. said actuating piston, supplemental linear actuator and pumping piston joined by at least one connecting rod so that the pumping piston is driven by the actuating piston and the supplemental linear actuator.
12. The pump of claim 11 further comprising a sump containing a supply of cryogenic liquid with said pumping cylinder housing submerged in the supply of cryogenic liquid.
13. The pump of claim 11 further comprising a liquid delivery line also in communication with the pumping cylinder outlet and adapted to communicate with a use device so that a portion of the pumped cryogenic liquid may be delivered to the use device.

14. The pump of claim 13 further comprising a pressure control circuit positioned within said liquid delivery line, said pressure control circuit selectively increasing the pressure within said liquid delivery line so that a greater portion of pumped cryogenic liquid may be directed to said heat exchanger.

15. The pump of claim 13 further comprising:

- e. a gas and liquid mixer in communication with the actuating cylinder outlet and the liquid delivery line so that said gas and liquid mixer receives cryogenic liquid from the liquid delivery line and cryogenic vapor from the actuating cylinder outlet so that the cryogenic liquid is warmed by the cryogenic vapor to a desired temperature; and
- f. a conditioned liquid dispensing line also in communication with the gas and liquid mixer so that the warmed cryogenic liquid may be dispensed therefrom.

16. The pump of claim 15 further comprising a pressure control circuit positioned in said liquid delivery line, said pressure control circuit selectively increasing the pressure within said liquid delivery line so that a greater portion of the pumped cryogenic liquid may be vaporized and ultimately directed to said gas and liquid mixer so that greater heating of the cryogenic liquid occurs therein.

17. The pump of claim 11:

wherein said actuating cylinder is divided by said actuating piston into a first chamber and a second chamber, each of which includes an inlet; and

further comprising a first automated control valve in circuit between the heat exchanger and the actuating cylinder inlets, said first automated control valve introducing cryogenic vapor into said first and second actuating cylinder chambers in an alternating fashion thereby propelling the actuating piston in the first and second directions in a reciprocating fashion.

18. The pump of claim 17:

wherein said supplemental linear actuator is a hydraulic cylinder including a hydraulic piston attached to the connecting rod with first and second chambers on opposing sides of the hydraulic piston, each of which includes an inlet; and

further comprising a second automated control valve adapted to communicate with a pressurized source of hydraulic fluid and the hydraulic cylinder first and second chamber inlets, said second automated control valve introducing hydraulic fluid into said hydraulic cylinder first and second chambers in an alternating fashion thereby propelling the hydraulic piston in the first and second directions in a reciprocating fashion.

19. The system of claim 18 further comprising first and second limit switches, a stroke change cam attached to said connecting rod and a controller, said controller in communication with the first and second automated control valves and the first and second limit switches, said stroke change cam tripping said first limit switch when said actuating, hydraulic

and pumping pistons have traveled to a first position and said stroke change cam tripping the second limit switch when said actuating, hydraulic and pumping pistons have traveled to a second position, said controller reconfiguring said first and second automated control valves whenever said first and second limit switches are tripped so that cryogenic vapor is redirected to a different chamber of the actuating cylinder and hydraulic fluid is redirected to a different chamber of the hydraulic cylinder.

20. The pump of claim 11:

wherein said supplemental linear actuator is a hydraulic cylinder including a hydraulic piston attached to the connecting rod with first and second chambers on opposing sides of the hydraulic piston, each of which includes an inlet; and

further comprising an automated control valve adapted to communicate with a pressurized source of hydraulic fluid and the hydraulic cylinder first and second chamber inlets, said automated control valve introducing hydraulic fluid into said hydraulic cylinder first and second chambers in an alternating fashion thereby propelling the hydraulic piston in the first and second directions in a reciprocating fashion.